ADU Final Report

Compiled for CE290D

For Review By:

Dr. Ashok Gadgil
Johanna Mathieu

May 13, 2009

Thomas Hendrickson
David Lallemant
Tim Racine
Eliot Rose
Anu Sridharan

Table of Contents

Abstract

Accessory Dwelling Units (ADUs) have emerged in recent decades as an economical solution for those seeking additional living space without buying more property. These small units are built in backyards, and are often referred to as “in-law units”, “granny units” or “backyard cottages”. The idea is logical for families experiencing an increasing burden in their current housing capacity, or for those seeking additional earnings from rent. Furthermore, as environmental and social problems created by housing have compounded recently, new needs for ADUs and increased density within urban areas have been discovered.

Our project focuses on using ADUs as an urban infill program, which would be a means for slowing urban sprawl, increasing affordable housing, creating revenues for homeowners in debt, and promoting already existing public transportation corridors. Energy efficiency and resource conservation of these units is also discussed as a means of creating more sustainable communities.

Background/context

Over the next 25 years the Bay Area’s population will grow by 2 million, and in order to accommodate this growth, the region will need to add 700,000 new housing units (ABAG 2009). If recent trends prevail, most of this housing will be in outlying areas such as Solano County (NCTA 2009 3-1, Droetboom 2009), exacerbating many of the region’s current problems, such as inequitable jobs-housing balance, congestion, and high levels of per capita greenhouse gas emissions. Though the Association of Bay Area Governments, the Metropolitan Transportation Commission, and other regional agencies all have long-term policies aimed at reversing sprawl and fostering growth in regional centers with better access to jobs and transportation (Droettboom 2009), it is unlikely that these policies will be sufficient to sustainably accommodate these new residents. California’s urban history is characterized by a strong level of local control over planning decisions, and regional agencies have very little regulatory power. Cities with high property values are reluctant to build housing, which generates fewer tax dollars than other uses such as retail, or provide the costly services and infrastructure needed by new residents, and have resisted doing so for the greater good of the region (Fulton and Shigley 2005, 93-6).

However, the market may be able to drive the changes that regional agencies have failed to produce. Studies show that suburban large-lot single-family housing is overbuilt, and project a growing demand for multi-family housing in walkable neighborhoods (Nelson 2005). The recent real estate crisis has also slowed growth and affected housing values, hitting homes in outlying locations the hardest.

Our mentors, Kevin Casey and Evan Schwimmer of New Avenue Homes, see accessory dwelling units (ADUs) as an appropriate response to the combined demands of the market, the region, and the environment. Homeowners faced with escalating mortgage costs can construct ADUs to provide themselves with an extra source of income, and do so without substantially altering their neighborhoods. Situating new rental housing in regional centers could help accommodate demand from the growing number of households that wish to live closer to jobs, services, and cultural centers. These households would be able to drive less and consume less electricity than their suburban counterparts.

Team goals

Our project goals have changed throughout the semester, as we have launched into our research and really begun to find out about the challenges and opportunities presented by this endeavor. Our goals, throughout the latest phase of our research have been the following:

Optimal:

To develop a preliminary ADU design: Architectural design & plans, associated costs

To draft an Environmental Impact Assessment:

At the unit level: Energy efficiency calculations, embodied energy

At a macro scale: Environmental impact of urban infill versus "Greenfield" development.

To achieve approval of ADU: building plans, get needed permits and site approval. Work with local planners and officials to make changes to zoning and building codes that would remove key barriers to ADU construction.

To conduct market research and identify target neighborhoods: Provide material supporting the scaling up of ADU development, find target neighborhoods and properties.

Minimum:

To produce a Guideline for City Permitting & Approval Process.

To issue recommendations for baseline energy savings.

To gather and compile survey information about technology adoption.

As evidenced by the progress and work contained in this report, we have gone a long way towards achieving the goals we have set. Some of the benchmarks we will continue to strive for as we continue the work of this endeavor beyond the class.

Barriers to ADU construction: zoning and permitting

Methods

We relied on interviews in order to better understand the process of designing, permitting, and constructing an ADU. We spoke with three categories of people in the course of this research:

- Ten Bay Area **residents**, either homeowners who had installed or were in the process of installing an ADU on their property or renters currently living in an ADU. We contacted some of these residents through mutual acquaintances and others simply by knocking on doors of West Berkeley homes with ADUs.
- Five **urban planners** from the City of Berkeley Planning Department who were responsible either for green building projects or projects in neighborhoods that we deemed opportunity areas for ADUs. Some of these planners were involved in public processes with the Berkeley community, while others had experience working in other Bay Area communities.
- Two **developers** whom planners had identified as involved in high-density or infill housing projects in the Berkeley community.

We supplemented these interviews by reviewing municipal zoning codes and policy documents from Berkeley in order to better understand the relationship between the city's policies and residents' experiences installing ADUs on their property. We also researched zoning codes in four other Northern California cities—Livermore, Santa Clara, Davis, and Palo Alto, which all have populations similar to Berkeley's and universities or research institutions within their borders—in order to determine whether these cities placed similar constraints on ADUs. Finally, we investigated the changes that Vancouver and Santa Cruz, both of which have policies that encourage ADU construction, have instituted in their zoning codes in order to remove barriers for potential ADU owners. Our interview scripts and notes are available in Appendix A.

Findings

Though ADUs vary widely from project to project depending upon lot and neighborhood characteristics, the homeowner's knowledge and desires, neighbors' concerns, and other factors, our research revealed a fairly consistent set of opportunities and barriers for homeowners who wish to install ADUs on their property. In particular, interviewees consistently identified the process of applying for and attaining a zoning permit as the largest barrier for homeowners attempting to install ADUs. Homeowners with ADUs also said that zoning and building codes had placed constraints on the design of ADUs. In general, homeowners were more concerned about the time and scrutiny involved in the permitting process than the required fees, and several said that the restrictive nature of municipal codes and the intensive effort involved in the permitting process had led them to construct their unit illegally.

We originally intended to conduct market research using a large sample of homeowners to better understand what potential clients want in an ADU. However, our research revealed that regulations distort this market substantially, intimidating would-be ADU owners with little knowledge of how the permitting process works and inducing others to act illegally. We therefore shifted our focus to helping our mentors work within the constraints of these regulations and overcome the barriers that our interviewees had identified.

Zoning, permitting and ADUs

The zoning codes that govern housing in American cities are usually conservative in nature. They are shaped by the concerns of existing homeowners, whose primary motive is often to preserve property values and limit nuisances (Fulton and Shigley 2005, 19). Zoning codes make it particularly difficult to increase neighborhood densities by building infill housing such as ADUs by limiting heights, ensuring large amounts of space between buildings, and requiring that all new units provide ample parking. Though restrictive zoning policies create regional problems, contributing to high housing prices and urban sprawl (Cervero 1989, Fulton and Shigley 2005, 208-9), they are seldom overturned for the simple reason that those who stand to benefit the most from increasing the local housing supply—i.e. potential new residents—don't yet live and vote within the communities that have the power to enact these policies.

The State of California has made efforts to overcome local resistance to ADUs. In 2002, the state passed Assembly Bill 1866, which amended second-unit law to require ministerial review of ADUs rather than more extensive discretionary review. Units that only undergo ministerial review in order to be approved are commonly referred to as “as-of-right” units. This bill was intended to mean that property owners wishing to construct ADUs will "not be subject to excessively burdensome conditions of approval" (California Department of Housing and Community Development 2003) by their local planning departments, with minimal permitting and time costs as long as the proposed project conforms to existing zoning standards.

However, these standards are often so strict that in practice few ADUs can conform to them. Staff from the City of Berkeley Planning Department report that AB 1866 did not lead to the surge in ADU construction that they expected, with only 21 permitted units built since the legislation went into effect (Powell 2009, Mendez 2009). In order to be as-of-right, ADUs in Berkeley must conform to requirements governing:

- Lot size: a lot with an ADU must be at least 4500 square feet.
- Lot coverage: the combined footprints of all structures on a lot must cover no more than 40 percent of the lot.
- Setbacks: ADUs must be set back four feet from side property lines and 20 feet from rear property lines
- Height: ADUs can be no taller than 12 feet.
- Floor area: ADUs are limited to either 640 feet or 25 percent of the floor area of the main unit, whichever is lower.
- Parking: ADUs must be accompanied by an additional off-street parking space (City of Berkeley 2008, 134-158).

Altogether, these requirements make it impossible for many property owners to conduct as-of-right ADUs, or restrict the size of an as-of-right ADU so much as to render it unlivable. The planners and property owners that we interviewed said that the parking requirements contained in Berkeley's zoning ordinance presented a particularly difficult challenge for those attempting to construct ADUs. Almost half of Berkeley’s housing stock was constructed before 1939 (Nielsen Inc. 2004), before automobiles became the predominant mode of transportation, and many lots lack off-street space for more than one car. Cities in the more suburban locations that we researched place similar restrictions on ADUs, with some minor changes that make it easier to built an as-of-right ADU counterbalanced by others that make it more difficult. For example, Livermore and Palo Alto both allow ADUs with larger floor areas than Berkeley does, and typically have larger lots with more space devoted to on-street parking.

However, these cities also require that homeowners provide two extra parking spaces in order to build one of these larger as-of-right ADUs (City of Livermore 2009, 3-15-3-16, and City of Palo Alto 2009, 12-14). Furthermore, our environmental impact analysis shows that siting ADUs in suburban communities does not yield as many greenhouse gas reductions and other environmental benefits.

Homeowners who wish to install ADUs on their property but do not meet the requirements for an as-of-right permit may instead apply for an administrative use permit (AUP). However, an AUP is more expensive and takes more time to attain, and also creates more opportunities for neighbors to oppose the project (Table 1). Few of the ADU owners that we interviewed reported conflict with their neighbors during the permitting process (West Berkeley homeowners 2009, Orjala 2009). However, developers and planners cautioned that objections from a single neighbor can slow the permitting process dramatically. Neighbors can appeal the project to the zoning adjustments board (ZAB), which can take up to a year to render a decision (MacDonald 2009, Sorenson 2009)

	As-of-right	Administrative use permit	Zoning adjustments board appeal
Cost	$152	$1,850	Depends upon variances required*
Review period	1-2 months	2-4 months	6-12+ months
Notification	Homeowner must get signatures from abutting and confronting neighbors	City notifies neighbors by mail as it sees fit and informs them of their right to appeal	Open to the public

Table 1: Costs, review periods and notification types of different zoning permits (City of Berkeley 2009a, Sorenson 2009, Mendez 2009)

*The board may require the homeowner to apply for one or more variances, which cost $1,629-$6,930 each

There are three phases in the process of building an ADU: design, permitting, and construction. The lengthy and variable review periods required by the permitting process pose challenges for our mentors' business model, under which the company both consults on the design and assists with the construction of the ADU. On one hand, assisting clients with the permitting process would ensure that time invested in design consultation does not go to waste if clients are subsequently discouraged by the permitting process. Doing so may also expand the company's market; many of our interviewees who had successfully installed an ADU on their property were architects or contractors, who relied on their professional experience while attaining permits (West Berkeley homeowners 2009, Orjala 2009). Offering assistance may attract clients who would otherwise be intimidated by the permitting process. On the other hand, advocating for a project before the zoning adjustments board would require substantial staff time and involvement in order to get a single ADU approved. The developers whom we interviewed routinely appear before the zoning adjustments board in order to advocate for their projects, and caution than doing so is only worthwhile for large projects that yield sufficient returns to compensate staff for their time (McKinley 2009, MacDonald 2009). Instead of making a recommendation for one business approach over the other, our team chose to focus on creating products that our mentors can use no matter which approach they choose.

Education and outreach materials

We compiled our findings from the Berkeley Zoning Code into a single flowchart that maps out the permitting process (Appendix B), including information on required fees, application materials, and review periods. This information is culled together from several city documents and conversations with planning staff. Having it all in easy-to-understand should make it easier for our mentors and potential clients to estimate the amount of money and time necessary to attain a permit for a given ADU, helping clients who are not familiar with the permitting process overcome knowledge barriers.

Analysis of ADU opportunity areas and potential mitigation measures

Using geographic information systems (GIS) data from the city of Berkeley, the U.S. Census, and the State of California, we created a map that shows areas within the city that are particularly well-suited for ADU development, (Figure 1). In order to determine which lots had adequate space for an ADU, we multiplied the building floor area by 1.25 to account for the fact that ADUs are allowed to be up to 25 percent of the floor area of the main unit. If the result was less than 40 percent of the lot area, we designated that parcel an ADU opportunity lot. Since peer influence seems to be a strong factor in the spread of ADUs through a neighborhood—many of the ADU owners with whom we spoke mentioned that they had been inspired to build their unit because of similar accessory structures on their neighbors' property (West Berkeley homeowners 2009)—we also mapped lots that already had ADUs on them. A block with a large proportion of ADU opportunity lots and ADUs already installed would be an ideal area for New Avenue Homes to target.

Figure 1: Close-up of a GIS map showing ADU opportunity lots (green), lots with ADUs already installed (blue), and other residential lots (orange), as well as quarter and half mile walksheds around BART stations (purple) and City Car Share facilities (turquoise).

This GIS analysis will also be useful for assisting clients in arguing for a waiver of the parking requirements for ADUs, which the homeowners and planners with whom we spoke identified as "the main challenge" (Mendez 2009, West Berkeley residents 2009) in the zoning requirements. If a homeowner cannot provide an extra parking space, she can still obtain at AUP by making the case that the parking space is not necessary due to other mitigating factors, such as proximity to transit and/or car-sharing facilities, low neighborhood levels of vehicle ownership and usage, or availability of on-street parking (Mendez 2009, MacDonald 2009).

Studies typically define "walking distance" as a radius ranging from a quarter- to a half-mile around a high-capacity transit station (Nelson 2006, Fairfax County 2006), and our geographic analysis shows half- and quarter-mile walksheds around BART stations (the semi-transparent blue areas in Figure 1), as well as City Car Share locations. It also contains census block group data on household vehicle ownership and journey-to-work data. Though planners tend to assume that every household will own a car (Sorenson 2009), this data could help clients in areas well served by transit prove that this is not the case in their neighborhood. The developers with whom we spoke also mentioned that they have provided City Car Share spots in exchange for reduced parking requirements (McKinley 2009 and MacDonald 2009), and our mentors might be able to do the same if they installed several ADUs within walking distance of a central location. By mapping the density of ADU opportunity lots, we're able to identify some of these potential new car-sharing sites. Finally, one planner mentioned that homeowners have successfully used parking surveys conducted by traffic engineers to argue that it was not necessary for them to construct an extra parking space when building an ADU (Mendez 2009). These surveys are usually too expensive for any one homeowner to conduct, but our mentors could conduct programmatic surveys in ADU opportunity areas in order to support clients' arguments that there is ample on-street parking in their neighborhood. The ability of GIS to overlay different layers of data is particularly useful since developers reported that they had the most success in persuading planners to waive zoning requirements when they pursued multiple mitigation arguments and strategies simultaneously. (This analysis was conducted as part of a city planning GIS class, and the complete paper, as well as several additional maps, are in Appendix C)

Opportunities to amend the zoning code

Some cities have created policy initiatives to encourage homeowners to construct ADUs. In June 2003, shortly after the passage of AB 1866, Santa Cruz's city council voted to revise its ADU ordinance and create "a simpler and shorter ADU permitting process" (Santa Cruz Housing and Community Development, 2009). The new ordinance eased parking requirements, allowing parking within a lot's front setback and tandem parking spaces, wherein cars are parked one behind another in a driveway instead of side-by-side, to count as a space (City of Santa Cruz 2009, Berg 2009). Santa Cruz also offers homeowners who agree to rent their units at affordable rates low-interest mortgages and waives fees for as-of-right ADUs (El Nasser 2004, Bernstein 2005). Vancouver, BC is currently revising its zoning code in order to encourage laneway houses, which are free standing garages converted to ADUs (City of Vancouver 2009a).

In Berkeley, which, like Santa Cruz and Vancouver, has a high level of public environmental concern and neighborhood activism, there are policy initiatives that pose opportunities to revise the zoning code in order to remove barriers to ADU construction. The mayors of Berkeley, Albany, Emeryville, and Oakland recently entered into the East Bay Green Corridor Partnership, which aims to "promote the East Bay as the nucleus of a 'green wave' of research and manufacturing" (Jones 2007). As part of this partnership, the city is updating the West Berkeley neighborhood plan in order to convert underused heavy industrial zones into light industrial areas that will be better suited to attract green businesses. The Green Corridor re-zoning is focused on attracting new jobs and does not contain any provisions for housing the workers who will fill these jobs, and neighborhood groups have expressed concerns that the process will make the neighborhood unaffordable for existing residents (Meigs 2009). Since West Berkeley has larger lots and more ample on-street parking than the average Berkeley neighborhood, it may be possible that re-zoning the residential areas to encourage ADUs would ameliorate residents' concerns about affordability, while providing more housing for new workers employed in the Green Corridor to live closer to their jobs. We have spoken with Berkeley planners and have interviews scheduled with community development staff to discuss the possibility of partnering with the city to provide ADUs in West Berkeley as part of the Green Corridor initiative.

The Berkeley Climate Action Plan, which council approved in May of 2009, calls for increasing housing density near transit (City of Berkeley 2009b). The Climate Action Plan is a guiding policy document, and as such does not mention what form this increased-density housing will take. However, given Berkeley residents' history of opposition to taller buildings in residential neighborhoods, it is possible that ADUs could emerge as a less contentious way of meeting this goal (Romain 2009).

However, it is unlikely that zoning will change in the short term. Zoning ordinances are complex documents and amendments are subject to public referendum, so planners must thoroughly evaluate potential changes to ensure that they don't have unforeseen negative effects. Implementing ADU policies in Santa Cruz and Vancouver took about two years, even with political support for the policies (Bernstein 2005, City of Vancouver 2009b). Even if we are successful in our outreach to city staff, it is extremely unlikely that zoning ordinances in Berkeley will change in time to have direct impacts upon our mentor's business. However, pursuing such connections is important for other reasons; it will help our mentor develop allies among the planning staff, which Santa Cruz Housing and Community Development Director says is crucial to any successful ADU program, regardless of the scale (Berg 2009).

Environmental Impact of Urban infill vs Greenfield Development

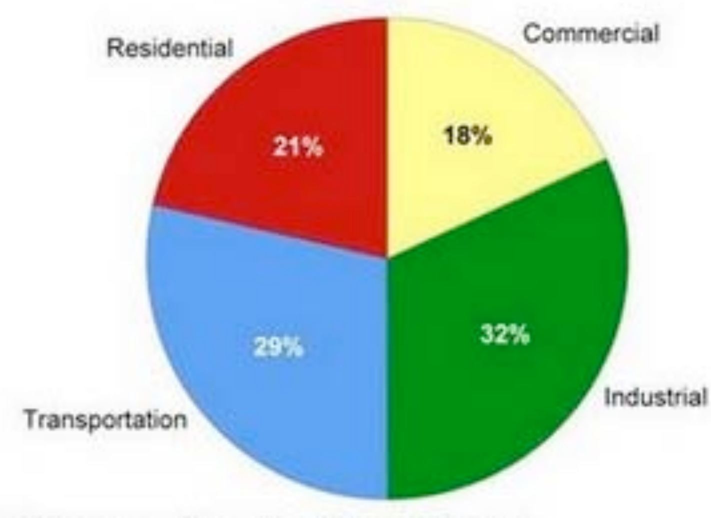
California is currently home to nearly 37 million people. Demographers have projected that this number will rise to 44-48 million by 2025. To accommodate this level of growth, California's counties and cities will have to plan for and approve approximately 220,000 new residential units annually to meet this demand[i]. The way in which these counties and cities decide to meet this housing need has profound environmental and social implications. Current investment in long-lasting infrastructure, such as housing, will create path dependencies that could "lock-in" inefficient energy usage for decades, with limited capacity for mid-course correction.[ii] The opposite is also true, and new housing also opens up opportunities to set urbanizing areas on a more sustainable path. We believe that ADUs could be part of the solution towards a more sustainable future for currently low/medium density neighborhoods.

Two of the seven million people moving to California will move to the Bay Area. In order to quantify the environmental impact of differing housing choices, we gathered data about the Bay Area, and used other studies on similar subjects to produce a rough Environmental Impact Assessment (EIA). Much of this work was adapted from studies done by Dr. John Holtzclaw, who has done extensive work on the impacts of land uses on transportation, materials and energy consumption, and pollution.[iii],[iv],[v]

We start from the premise that there are two basic approaches that the Bay Area can follow to increase its housing stock. These are green-field development (expanding cities) or urban infill (densifying cities). We don't mean to suggest that other options such as building new cities or new urban neighborhoods should not be explored. However, these later options for urban growth are rarely available, and are unique approaches that should be studied independently.

The following chart shows energy use by sector. The environmental impact of infill housing spans between two sectors. In a very simplistic sense, the physical attributes of a house impacts the building sector, and its location has an impact on the transportation sector. However, infill housing affects these sectors through many other less obvious though very profound ways. We will discuss these relationships in the following section.

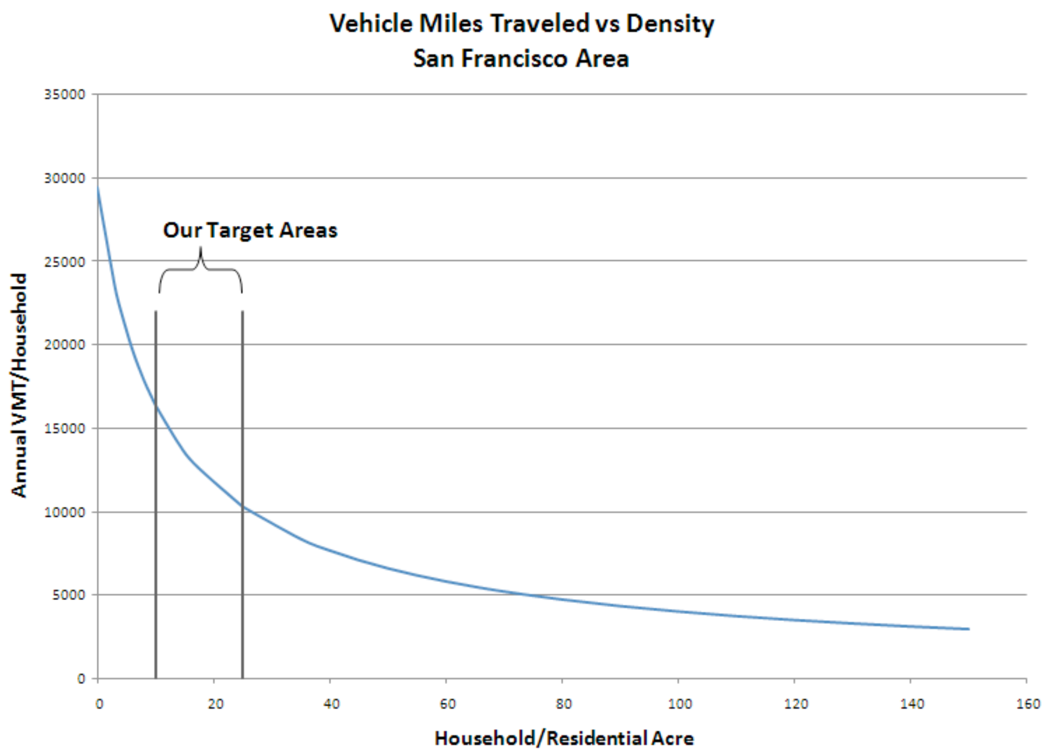
US Energy Use by Sector in 2007



Source: U.S. Department of Energy

Urban Infill vs Greenfield development - Transportation:

Numerous studies have shown the relationship between high density and low car usage. Denser neighborhoods own less cars, and drive less. The following graph was constructed using an algorithm developed by J. Holtzclaw. It was made specifically for the Bay Area and shows the relationship between driving and residential density.



Apart from the clear decrease in Vehicle Miles Traveled (VMT) as density increases, another important result can be drawn from the graph. The rate of decrease in car usage is greatest in lower densities. So two conclusions can be drawn:

1. Large environmental benefit when moving to a dense neighborhood as apposed to Greenfield development with a typical density of 3hh/res. Acre.
2. By densifying a neighborhood, VMT in that neighborhood can be reduced. The greatest reductions occur in low and medium density areas.

The neighborhoods that we are focusing on for our project are low/medium density neighborhoods in the Berkeley/Oakland area. From the graph above, targeting these neighborhoods should have the greatest impact on diminishing VMT of these neighborhoods. Taking the Rockridge neighborhood as an example:

Scenario 1: 300 households move into a newly built Bay Area suburb, with a typical residential density of 3 household per residential acre. This results in driving patterns of 23550 annual VMT per household, or a total of 7.1 million VMT annually.

Scenario 2: These 300 households move into ADUs built in Rockridge. Rockridge has a residential density of 14 households per residential acre and the 50 extra families bring this up to 17hh/res.acre. This density is associated with 12750 annual VMT/hh or 3.8 million VMT annually. This is a reduction of 3.3 million VMT every year. However, there is an additional benefit since densifying Rockridge reduces VMT for the entire neighborhood. Obviously the changing of driving patterns takes time, but we can expect that the increase in retail, jobs, transit demand that the 300 households will bring will reduce driving demand. This reduction, from 14100 VMT/hh for a 14hh/res.acre neighborhood to 12750 annual VMT/hh for a 17hh/res.acre neighborhood is equivalent to 2 million VMT annually.

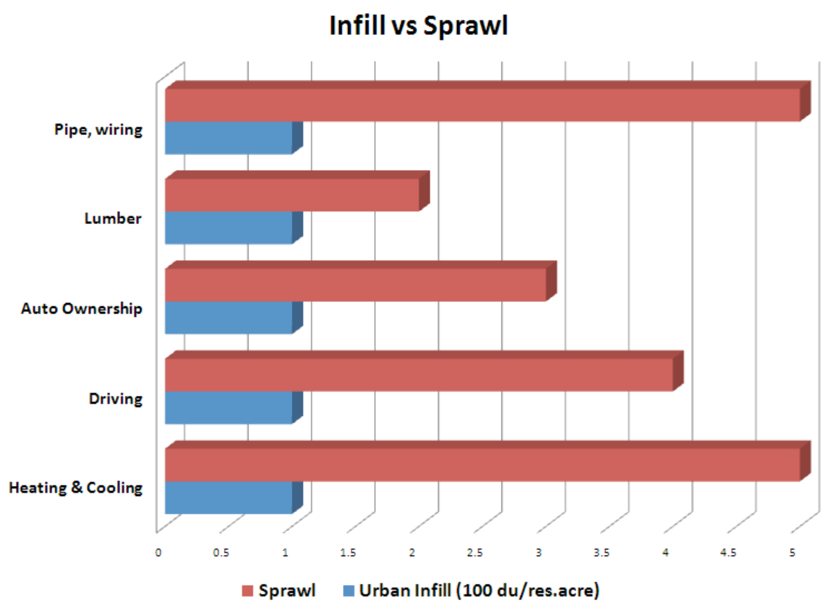
Therefore when 300 households move into Rockridge rather than into a new suburb, there is a total reduction of 5.3 million vehicle miles traveled every year! What does this mean for the Bay Area? Similar calculations can be done for the 2 million people moving into the Bay Area. Here again are some scenarios:

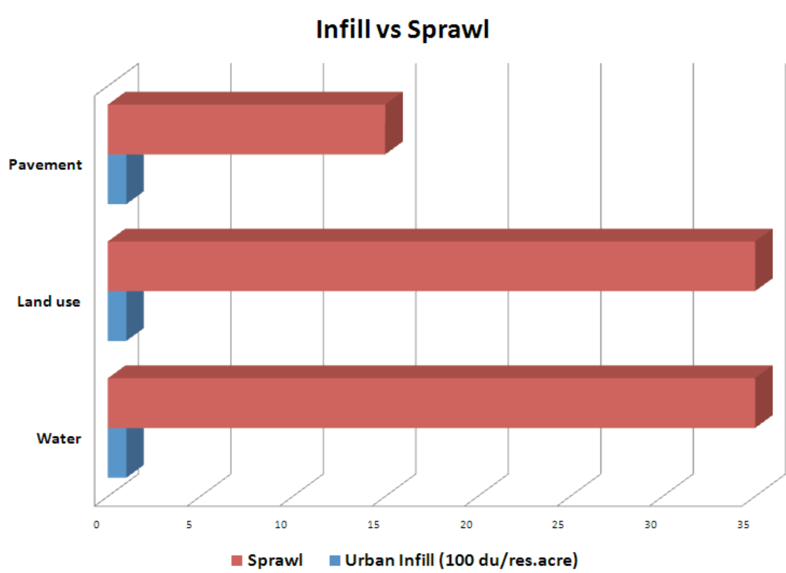
> Scenario 1: All of the 2 million move into Greenfield developed suburbs -> 14.7 trillion VMT annually.
>
> Scenario 2: 50% housed through Greenfield development and 50% housed through urban infill in medium density neighborhoods (such as Rockridge):
>
>> 11.3 trillion VMT annually.
>>
>> 1.9 trillion VMT reduced through densifying medium density neighborhoods (+20% hh/res.acre).
>
> Total reduction compared to scenario 1: 5.3 trillion VMT Annually!

It should be noted that these calculations are rough. Further information is needed regarding the demographics of the incoming 2 million people, moving behavior and more. For this analysis, simple assumptions were made about household size (One house for every 3.2 ppl), infill neighborhood type (Rockridge type neighborhoods) and level of densification that can be achieved through infill in these neighborhoods (+20% densification). A more refined analysis should be made, but these trends demonstrate that infill development through ADUs can have a large positive environmental impact through decreased auto usage.

Urban Infill vs Greenfield development – Other Environmental Benefits:

Most of the research on the effects of density on the environment has focused on transportation. However, choosing urban infill over greenfield development has many other environmental benefits. Virgin land can be saved from development. The provision of infrastructure to previously un-serviced land has a large negative environmental impact compared to using exciting infrastructure, or even upgrading it. The two following charts show some of these trends.





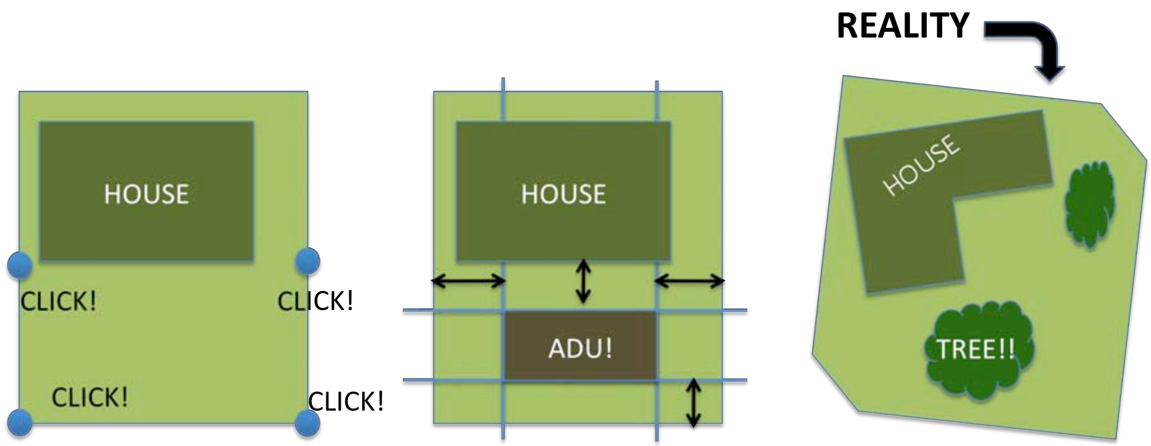
Source: Adapted from Holtzclaw, How Does Smart Growth Impact Climate Change Emissions? 2007

The units for these charts are dimensionless. They have been standardized and scaled to one unit for infill housing: i.e. for each km of pavement used for urban infill, 15 km would be needed for sprawl; for each liter of water needed for urban infill, 35 liters would be needed for sprawl. These values are for urban infill in dense neighborhoods (100 units per res.acre). As mentioned earlier, the neighborhoods that we are targeting are in the range of 10-25 units per residential acre. Therefore, for our own infill interventions these benefits would not be so large. We were not able to find adequate data relating to the impact of infill on land, water and infrastructure usage for our target densities. However these trends are the same and have been confirmed in other studies.

Market Research Tools

Our method for targeting neighborhoods and determining the market for ADUs has evolved throughout the semester. We first used rudimentary tools to estimate how many properties in a particular neighborhood could fit an ADU. We did this using satellite images from google-earth, and fitting ADU sized outlines in backyard plots.

Later, we developed a more sophisticated tool, which could streamline this process (using a few clicks of the mouse), as well as evaluate lots for setback requirements.



By talking with John Hanke, the founder of Google Earth, we identified a relatively efficient method for designing this tool. However, after using it with images of actual Berkeley area neighborhoods, it became clear that this method was very limited. It relies on the assumption that plots are clearly visible and demarcated, but the resolution of images is too low, and trees, irregular houses and property boundaries make it virtually impossible to accurately use this tool. Essentially this tool was no more efficient than our initial “rudimentary” method.

Finally we did some GIS analysis which identifies “potential” lots. These don’t necessarily meet all the requirements, but have a high probability of doing so…

Alternatives Assessment and Client Criteria

As the business model and implementation plan does not have the means to directly control the supply, manufacturing and construction of ADUs, we had to reach out to potential partners. Overall, we have identified

- Valley Home Designs – general contractor specializing in single family homes out of Sherman Oaks, CA. http://www.manta.com/coms2/dnbcompany_hht8q4
- Living Homes – architects and prefabrication home constructors. Have assembled homes on-site in 8 hours. Specialize in sustainable design, home assessments, and consulting. Built the first LEED platinum home. http://www.livinghomes.net/
- Michelle Kaufmann – architects and prefabrication home constructors out of Oakland, CA. Specialize in energy efficient small home designs. http://www.mkd-arc.com/
- California Cottages – specializing in providing clients with small backyard and modular homes through prefabrication partners. Walnut Creek, CA. http://www.calcottages.com/
- Backyard Homes – specialize in affordable home construction through prefabrication and stick-built methods. Focus on using local materials and contractors. Lakeside, CA. http://www.vhdonline.com/
- Zamore Homes – architect and contractor in small home construction. Designs for efficiency in space and energy. Uses stick-built methods. http://www.zamorehomes.com/
- Flat Pak House – architects and construction contractor. Offices nationwide and San Francisco. Provides a made-to-assemble service where client is consulted for needs. Prefabrication panel and appliance options are provided based on needs. http://www.flatpakhouse.com/
- Parco Homes – architect and prefabrication construction contractor. Specialize in sustainable housing options. http://www.parcohomes.com

	Cost	Size (ft^2)	Cost/ft^2	Construction	Customization
Michelle Kaufmann	+	500	$161.43	+	-
California Cottages	+	700	$133.97	+	-
Backyard Homes	++	627	$145.00	+	-

Zamore Designs	-	400	$250.00	-	++
Flat Pak House	++	varies	$250.00	+	-

The criteria used to judge each alternative was based on a basic needs assessment for homeowners determined by the group. Each alternative has had some level of contact, but the 5 listed above had given strong feedback on price quotes and design details. Flat Pak House had extensive information on their website, but had been vague in follow up emails after initial inquiries to learn more about their design details as we have not been able to detail the available sizes of their designs. Some numbers in the table can be misleading, as Zamore has the lowest cost/ft^2 but their quoted prices did not include the design costs. The Flat Pak alternative is the most inclusive cost that details appliances along with materials, construction, and design in the cost/ft^2. The prefabrication methods show the greatest ease in constructability, but sacrifice customization. Zamore homes may have a longer on-site construction period, but have a higher associated cost as the designs can be more customized without prefabrication. Many of the prefabrication designs must go through transportation assessments to determine if it is feasible to transport the large pieces of the house together to the site. This can be difficult in Berkeley with the common steep grades.

Environmental Assessment of Alternatives

From discussion of materials available, we can assess the environmental impact of different design and construction options. Currently, we have assessed 2 separate materials and 2 separate contractor options. Stick-built homes reflect the traditional wood-framed materials and insulation that is used in residential construction and design. Structurally Insulated Panels (SIPs) are a more recently developed pre-fabrication method that uses recycled wood for siding, filled with insulation, and removes the need for studs in structural design.

CO_2 equivalence (kg CO_2/ft^2/year)

	SIP prefab	Stick (non-prefab)	Backyard Homes	California Cottages
Construction	1.10	0.34	0.34	0.34
Transportation	0.10	0.00	0.10	0.10
Use Phase	18.20	26.45	26.45	26.45
Total	19.40	26.79	26.88	26.88

Energy use (kWh/ft^2/year)

	SIP prefab	Stick (non-prefab)	Backyard Homes	California Cottages
Construction	3.14	0.96	0.96	0.96

Transportation	0.27	0.00	0.27	0.27
Use Phase	52.00	75.57	75.57	75.57
Total	55.41	76.53	76.80	76.80

The two contractors are identical as both use stick-build in house pre-fabrication methods. The use phase dominates the differences in environmental impacts, mainly due to the thermal conductivity of the materials (Bourne et al. 2008). SIPs are less likely to lose heat when compared to stick-built. However, it is hard to truly distinguish the SIP construction from the other alternatives when the associated uncertainty of a life cycle assessment is taken into account. The heat loss from stick-built and other prefabrication methods can be avoided by attaching exterior polystyrene foam to stick-built walls, which increases the insulation properties of stick-built homes. The energy use calculations were found by using a conversion factor taken from the Energy Information Administration (EIA 2007).

Design for Environmental Efficiency

From the outset of the project it was made clear by the group and mentors that promoting sustainable technologies in the implementation of ADUs would be a major goal. The initial environmental assessment showed that the use phase had the largest impact, with little difference in the actual construction. The goal of the group and future business was centered on determining how efficient design options could be integrated into the project.

Initially the group promoted the idea of “zero-energy housing” as a goal in seeking energy efficiency options. Soon it became clear that this was an unrealistic goal, and a possibly poor marketing tool in appealing to clients. In discussions with Ashok Gadgil, Iain Walker, and Rick Diamond of Lawrence Berkeley National Laboratory the new focus became to work with designers and manufacturers in providing efficiency options to clients at minimal cost or with a strong return on investment. The easiest ways to obtain this was to seek to maximize windows and insulation to reduce the need for heating and cooling appliances. This concept is in accordance with the environmental alternatives assessment, where greater insulation was dominant in reducing use phase impacts.

Efficiency Assessment Tools

Maximizing windows and using more insulation in the walls were two go-to strategies that virtually guaranteed a more energy efficient ADU. Yet, there were dozens of variables that went into determining energy and other performance characteristics of an approximately 600 square foot house – e.g. orientation of the unit, shading devices, tint and composition of windows, type of flooring and pitch of roof. In our search of ultimate energy performing designs, we also discovered that researchers' ideas may differ on the subtle points. For instance, we encountered a variety of perspectives on the question of whether or not our ADU should utilize heat pump heating or whether the entire unit should be heated and cooled without the aid of mechanical devices. These quandaries aside, we were guided by Lawrence Berkeley Researchers Iain and Rick to consider two tools useful in designing an efficient building – Home Energy Saver and Energy Plus, both concocted by the U.S. Department of Energy.

Heartily taking the suggestions of our LBNL consultants and eager to see for ourselves how we might apply these two energy performance programs to our investigative design process, we elected to do a trial run of each.

Home Energy Saver

To strive for maximum realism in both the Home Energy Saver as well as for the Energy Plus model, we chose to use environment and design parameters of our test subject Karen Chapple's lot in Berkeley. The remaining largely hypothetical parameters we mostly chose to specify based on one or more of the ADU designs we had already studied either from an existing building such as Zamore Designs, or we specified the parameter for realistic design scenarios given the low cost and locality constraints of a potential ADU client lot. Some of the inputs and key building attributes used to develop the Home Energy Saver model and cost savings checklist are:

- City of Residence = Oakland, CA
- Price of electricity = $0.118/kWh
- Orientation & Number of Stories = West, 1-story
- Dimensions = 17 ft. x 28.8 ft.
- Number and size of windows on each side = Specified as per Zamore Design
- Envelope Construction & R-Value = Wood frame, R-11

With these and a few other values concerning the heating, cooling equipment, major appliances, and lighting specified, the Home Energy Saver runs an algorithm to output a series of suggestions ranked by financial return on investment for energy savings with their associated costs. The primary suggestions that emerged from our trial home assessment (which did however, very closely resemble Brett Zamore's Kit Home Design) were the following:

- Select a water heater with an energy factor (EF) of at least 0.95 (ROI = 94%)
- Replace incandescent lamps with compact fluorescent lights (ROI = 92%)
- Install an Energy Star ® -labeled programmable thermostat (64%)
- Choose double-pane solar control low-E argon gas wood window frame (ROI = 29%)
- Use Energy Star ® Refrigerator (ROI = 14%)
- Increase attic floor insulation to R-38 (ROI = 11%)

Upgrade Report: Your Energy Bill ($/year)
Location: Berkeley, California

Existing Home **$949**
with Selected Upgrades **$626**
Source: http://hesw1.lbl.gov/input3.taf?f=UpgradeReport&session_id=1355143

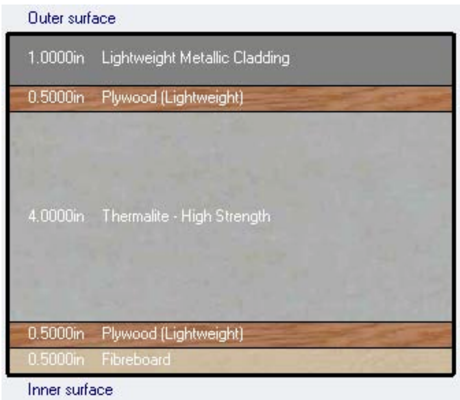
The above output graphic illustrates the distribution of cost savings across the various arenas of home energy consumption – heating (red), cooling, water heating, major appliances, lighting, small appliances (violet) when read from left to right. The advantages of this Home Energy Saver program are clear – it provides an analysis of a potential ADU in its hypothetical environment and allows us to critique the various aspects of one design and identify the best improvement areas. These improvement areas can be carried forward and incorporated into a new design for a client, with a clear understanding of the prospective costs associated with that design change. There is, however, one severe limitation to this model's usefulness in our applications – the design changes yielding the most improved energy performance may not be identified in Home Energy Saver simply because the assumption is made that the unit is built and occupied. Costs to alter the building envelope may be estimated significant higher for a built unit than would be in the design phase. An example is seen in the last recommendation of the Home Energy Saver to increase the roof R-value from 11 to 38. In determining the investment return on this strategy, the model must account for the cost of tearing out the existing roof and adding the new one, whereas in our ADU design scenario, there is no cost of altering existing structures. Nonetheless, with these targeted energy saving strategies, we were able to identify the a few of the primary green features we could encourage in guiding users wishing to build green or even just to save some money through a design.

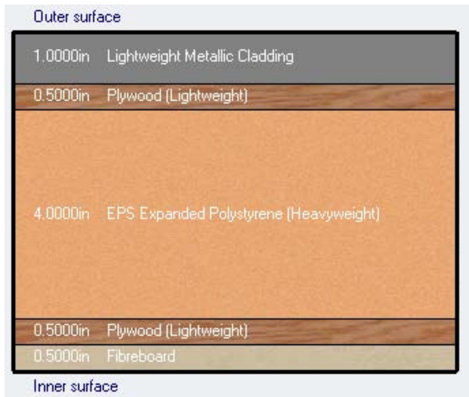
Energy Plus

A more design-adaptive yet slightly less user friendly home energy modeler that was recommended by Rick Diamond is the Energy Plus energy modeler. This software, also developed by the Department of Energy, models heating, cooling and energy flows in a building. At first glance, this software didn't seem like a tool we could easily use in developing an energy efficient design for an ADU. However, with an accompanying graphical user interface (Design Builder), we were able to develop a three dimensional building design, apply material properties and characteristics to the building attributes and then run a full 12-month simulation based on real local atmospheric and weather conditions. Again, for this exercise, we applied the parameters characteristic to Karen Chapple's home lot such as ADU orientation, and geographic location. A much more robust software than Home Energy Saver, Energy Plus invites users to specify a high-level of detail – e.g. you can specify precisely how many layers and of which material your ADU walls will be comprised of. Some design characteristics we specified in our base case model, again based on designs obtained from existing builders or Brett Zamore:

- Five layer exterior walls – thin metal cladding, plywood, thermalite insulation, plywood, and fiberboard (based on Brett Zamore's design, R = 6.67)
- Clay tile roof, stone wool roofing insulation, roofing felt (R = 28)
- Wooden flooring
- Double pane, low-E argon glazing
- Fan coil heating
- Natural cooling

With these and other design parameters specified, Energy Plus allows you to perform calculations on the building's performance based on winter and summer time conditions in the specified climate (Oakland, CA). Additionally, running a 12-month simulation yields detailed forecasts on five relevant building performance categories: fuel consumption (by building component), temperature (air vs. outside temperature), heat balance (by building component), relative humidity, and total fresh air available. A scan of the output graphs from our baseline simulation is included in the Appendix for reference. The potential use of the Energy Plus tool was truly tested when we decided to experiment with arguably the most significant design feature of the ADU, the wall composition – given the wall area to floor area ratio, that is. We wished to gauge the performance of an ADU whose walls contained expanded polystyrene (EPS) insulation and a total R-value of 20 and compare it with the performance of the baseline ADU whose walls are of the same thickness yet different material (and lower R-value).





Thermalite (Left) R-6.7 Wall versus EPS (Right) R-20 Wall, Source: Design Builder ©

The results of the simulation which can be seen in the Appendix, suggest an increase of up to 4 degrees Fahrenheit through the winter months of November – February as well as a clear decrease in the heat loss through the exterior walls for the ADU model with EPS walls.

Though the Energy Plus model seems to give a fairly accurate representation of the projected energy use conditions of the building throughout its day-day life, the output is still a mere forecast which fails to capture aspects of reality. As we were reminded by the energy specialists we consulted, the energy use of an ADU could vary significantly based simply on how many fish tanks or plasma screen TVs she is using.

Other Energy Saving Design Options

Other options included reducing the burden of appliances by seeking to use the most economical and efficient option. Energy STAR provides easily accessible information in cost and energy savings for clients on approved appliances. Directing clients to this type of information through discussion and education in the design phase can allow for easy promotion and diffusion of new and simple energy efficient technologies.

		Initial cost	Bill cost/month
Refrigerator	EnergySTAR	$1,100	$43
	Conventional	$1,070	$51
	difference	$30	-$8
Dishwasher		Initial cost	Bill cost/year
	EnergySTAR	$545	$30
	Conventional	$545	$54
	difference	$0	-$24

Source: Energy STAR 2009

In pitching energy efficiency options to clients it must be made clear the economical benefits of employing different options. Although environmental benefits may be a strong basis of many clients' beliefs, it cannot be relied on as a means for diffusion of these technologies. In several discussions for future possibilities for the business, aiding in initial costs for technologies could be a way to promote use and eventually gaining a return on investment for both client and the business. If the client is aggressive enough to employ technologies such as solar power, information and education for government aid and subsidies could be provided.

Many of the designers and prefabricators were responsive when an environmental focus was discussed in design. Michelle Kaufmann Designs (MKD) actively promoted environmental design and technology in all aspects of their process and recently performed energy analyses of their products in the consumer use phase. Their designs seek to reduce material and energy use (Michelle Kaufmann Designs 2009). California Cottages sought to provide clients with simple appliance options to save energy costs. It is important that environmental awareness and energy efficiency is not just a marketing tool but also a strong part of the focus and future work of the business.

Market Surveys:

Our group decided that in order to deploy these ADU's, we needed to understand the potential market and conduct preliminary market research. We chose the neighborhoods of West Berkeley, Albany, and Oakland to start our interviews. We interviewed 10 residents and there were a few main points that surfaced. We realized that the ADU's were pretty well accepted in these areas and so putting one in the backyard wouldn't be a problem for the neighbors. We also found out that a lot of people did so illegally because they felt it was really hard to go through the city to do it. Many of them just claimed to be expanding a garage, or doing some other type of home improvement.   Interestingly enough, when one neighbor did it, others realized that they could do it as well. However, if one person's ADU was illegal, chances are the other neighbors would also do it illegally - causing the 'band of thieves' effect. They understood that their property value would not increase, but it was still worth due to the decreased hassle and the revenue generated through rent.

The people who did decide to put in ADU's legally typically had some connection to the building industry and therefore could navigate the system easily, or found it cheaper. One resident we talked to was a general contractor himself, and another resident we talked to was an architect who designed the ADU. One problem the architect encountered was the receiving city approval for the landscaping. She said that in the future, people shouldn't put any landscaping because it's easier to approve and landscape can always be added later.

Some people we talked to who didn't have ADU's on their property said they valued their backyard space; they wanted to keep it for the dogs to run around in and the kids to play in. They did indicate that they could see themselves moving into one when they got older.

Current Business Model:

The current business model deals with the financing, permitting, and construction of the ADU. The for profit entity provides a micro invest network that allows investors to invest in the construction of an ADU.

This section intentionally made blank -- to remove company-confidential information.

The rent generated from the ADU is divided between New Avenue, investors, and the homeowner.

This section intentionally made blank – to remove company-confidential information.

After this happens, New Avenue also deals with the permitting, and the actual construction of the ADU.

Problems:

First, there seemed to be a negative perception of the term 'infill housing" and 'urban densification'. Technically, ADUs are a form of urban densification and infill housing. However, when the public hears these terms, they immediately conjure images of high rises and Manhattan style living.

Another misconception seemed to be that many individuals believed that residential energy efficiency was prohibitively expensive. Many were unaware of how to obtain the monetary incentives that the local, state, and federal government were proposing. Most people believed that energy efficiency was important, but couldn't afford to be energy efficient.

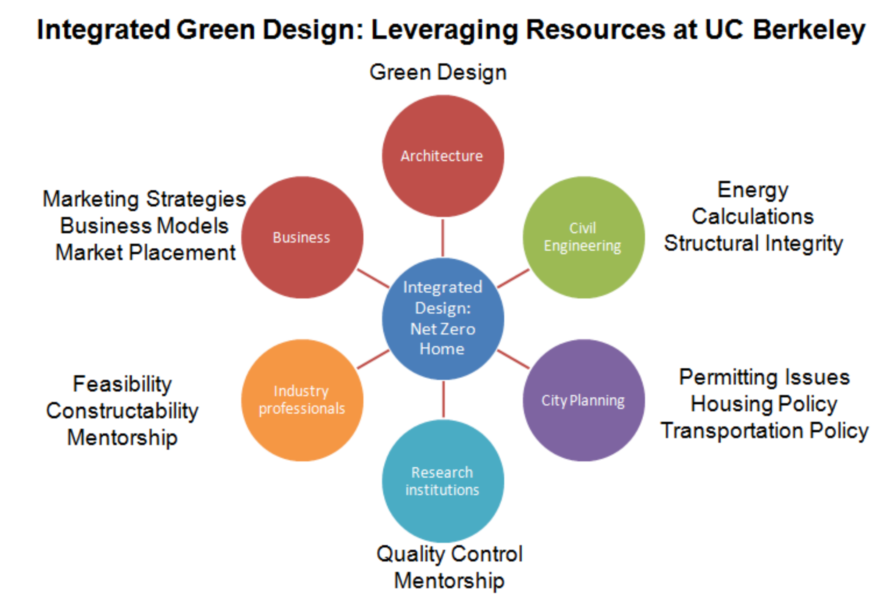
From our conversations with LBNL researchers, we discovered that there was a huge gap between academia and commercial mass market. Many of the technologies that are created at LBNL never reach the market for consumer adoption.

Solution:

Using UV Waterworks as an example, our proposed solution is to create a hybrid non profit/for profit business model to address the issues of perception/energy efficiency knowledge and transfer of best green design practices.

Similar to the way in which UV Waterworks uses non profits for education and social marketing, one arm of the non profit would deal with educating the public about energy efficient technologies, financing options, and monetary incentives for energy efficiency. This non profit would partner with local entities doing similar work, such as LBNL energy education programs, Berkeley Build it Green, and Livable Berkeley.

The second part of the non profit would focus on leveraging the resources at UC Berkeley to create an integrated green design process. The philosophy behind this part of the non profit is the same philosophy of CE 290: cross sector collaboration breeds innovation.



By involving multiple colleges around campus, the goal is to eventually build affordable, aesthetically pleasing ADUs that the mass market will be willing to adopt.

The non profit will engage multiple colleges around campus and will coordinate the efforts of these individuals and bring together the multiple stakeholders in this process.

Commercialization will be achieved by placing these green designs on New Avenue Homes' website next to other architectural designs. Then, consumers can actually construct these Berkeley Green homes, and students will receive actual market feedback on their designs.

The eventual goal is that Berkeley innovation will skew the market such that most homeowners will prefer the Berkeley design due to its energy efficiency, cost, and aesthetic value. If this happens, many architects and designers will be forced to adopt these same ideals if they are to compete in this market.

Future Work:

We plan to continue working on the project this summer. We will be constructing an ADU for Karen Chapple from the architecture department. We are currently trying to obtain venture funding (approximately $500,000) to become an actual incorporated business. We are also going to start community work and start engaging other non profits in the area to coordinate efforts in education and outreach.

Appendix A: Interview scripts for ADU owners and renters, urban planners, and developers

Interview Script for ADU owners and renters

My name is Eliot Rose, and I'm a UC Berkeley Master's in City Planning student conducting research on accessory dwelling units (mother-in-law units, granny units, secondary units, etc.) for a project on the barriers and opportunities for adding more of this type of housing in the Berkeley area in a class called Design for Sustainable Communities. If you don't mind I'd like to ask you a few questions about your ADU. I'll be taking notes on our conversation, but the information that I'm collecting is strictly for preliminary research purposes, and I won't be publishing it, just using it to refine the scope of the project as my group moves forward. You're free to decline to answer any of my questions. Is that OK with you? Do you have any questions before we begin? Thanks in advance for your time.

For ADU Builders

Why did you choose to build your ADU?
Did you have any conversations with your neighbors before building your ADU?
Did you attempt to get a building permit from the city?
If no: Why did you choose not to get a permit?
Did you initiate the permitting process and decide that it wasn't worth it?
Did not having a permitted ADU force you to modify your plans?
What kind of risks did you take by not getting a permit?

If yes: What were the steps that you had to go through to get your ADU permitted?
Did any unforeseen or last-minute obstacles arise?
Were you forced to change your plans for the ADU at any point in the process?
What were the costs of getting your ADU permitted? How long did it take?

(Proceed to questions for ADU owners/landlords)

For ADU Owners/Landlords

If not a builder:
was the ADU a factor in your decision to buy this house?
Have you renovated your ADU?
What purpose do you use your ADU for?
Can you tell us what the square footage and monthly utility bills are for your ADU?
If a landlord:
Did you have to make any modifications to your ADU in order to provide access?
How important is the rental income from your ADU in enabling you to make your home payments?
Do you feel like your privacy is protected?

For ADU Renters

Were you actively looking to rent an ADU instead of an apartment or efficiency? If so, why?
How is the ADU different from other housing that you've lived in?
If you could redesign anything about your ADU, what would it be?

For Neighbors

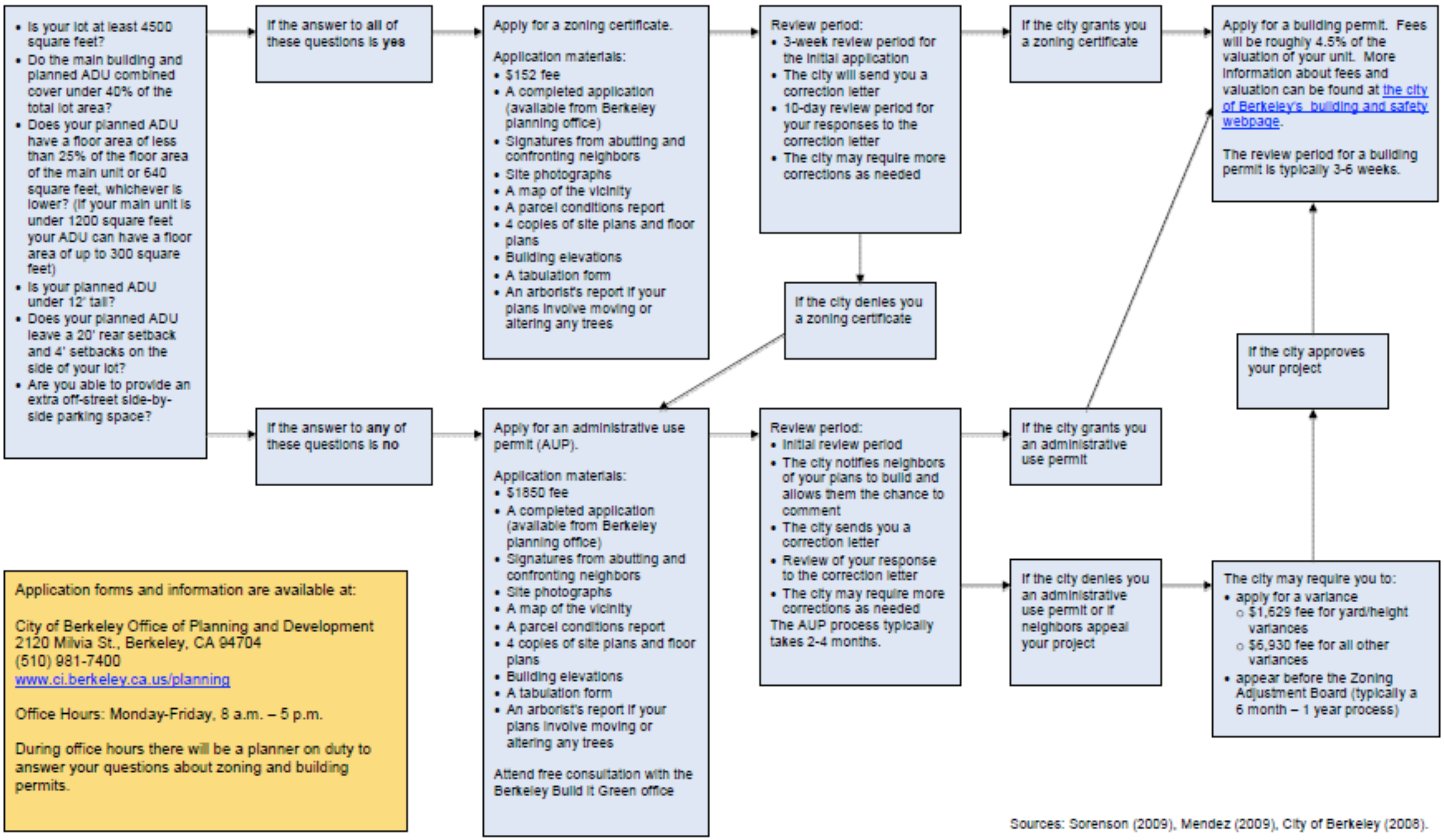
How do you feel about living next to homes with ADUs?
Did the builders or owners of these units contact you before building the ADU?
Would you consider installing an ADU on your property? Why/why not?

For all respondents

If you could pick a specific issue with ADUs for us to research in more depth, what would it be?
Can I get your contact information so that I can follow up if I have additional questions?

Appendix B: Zoning Permit Flowchart

Accessory Dwelling Unit (ADU) Zoning Permit Flowchart



Appendix C: Mapping the Granny Flats

Work conducted by Eliot Rose as part of the Design for Sustainable Communities class (CE290) and the GIS Methods class (CP204C).

Mapping the Granny Flats

Opportunities for accessory dwelling unit construction and permitting in Berkeley

Introduction

Goal: to identify opportunity areas for ADU growth

Over the course of this past semester, a group of engineers and I have been advising two Haas students who are starting a business financing and installing accessory dwelling units (henceforth referred to as ADUs, a.k.a. granny flats and mother-in-law units) across the Bay Area. As the lone planner in the group, I've been the most skeptical about the endeavor, because zoning codes put such heavy restrictions on homeowners who wish to put an ADU on their property. I decided to use GIS conduct to identify, based upon the constraints imposed by the zoning code, opportunity areas for ADU growth so that my partners can target these areas in their marketing and outreach. I restricted my analysis to Berkeley since the company is starting up here and because I've done more work researching codes and speaking to planners in Berkeley than in any other Bay Area city.

My group has interviewed a series of planners, developers, homeowners who have built ADUs, and tenants of ADUs to better understand the main barriers to ADU construction. Our interviewees have identified two principle challenges imposed by the zoning code: lot restrictions and parking requirements. The city requires that a lot with an ADU be at least 4500 square feet, and that all structures cover no more than 40 percent of the lot's total area (City of Berkeley 2008, 141). It also requires that homeowners who put an ADU on their property provide an extra off-street parking space (City of Berkeley 2008, 141). Berkeley lots are typically small and the majority of Berkeley homes were built before the automobile era. Some homeowners could add an ADU and meet the lot requirements, but few own a parcel with room for extra off-street parking, and those that do would likely be reluctant to pave over a portion on their yards. Therefore, I assumed that in order to obtain a permit, my partners' clients would have to argue that the parking requirement be waived. My analysis had two sub-goals:

1. To identify areas with a high density of lots with space for ADUs.
2. To identify areas of low vehicle ownership that are well served by transit and other alternative mode facilities.

I defined an opportunity area for ADU growth as one where the two areas described above overlap. In order to conduct my analysis, I needed to go through the following steps and use the following techniques:

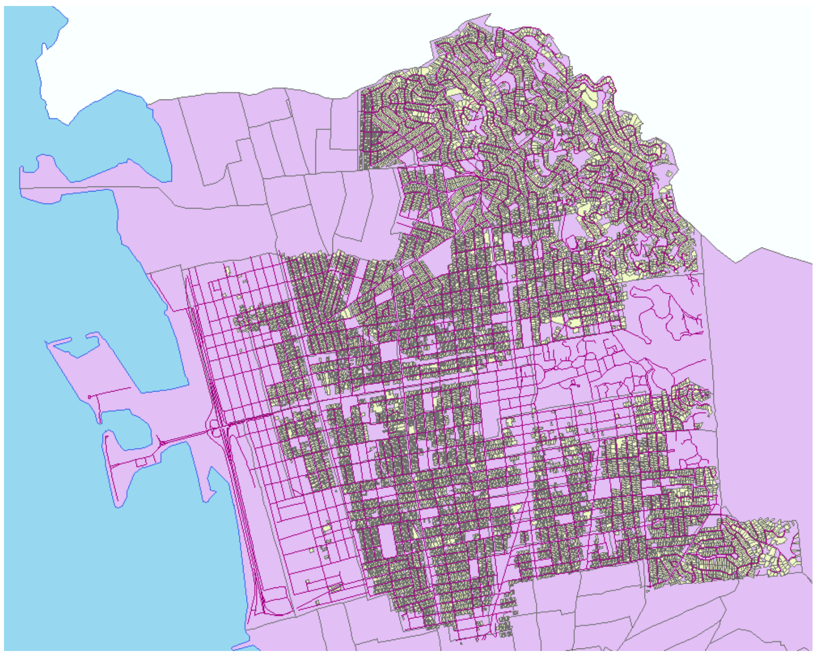
1. *Assembling my map layers* by acquiring the necessary data and re-projecting it so that it aligns correctly.
2. *Displaying ADU opportunity lots and demographic information* by incorporating census data into my shapefile databases and managing those databases.
3. *Creating new map features* using georeferencing.
4. *Displaying walksheds around alternative transportation facilities* using network analysis of these facilities' service areas.
5. *Analyzing the density of lots with space for ADUs* using spatial interpolation.

Step 1: Assembling map layers

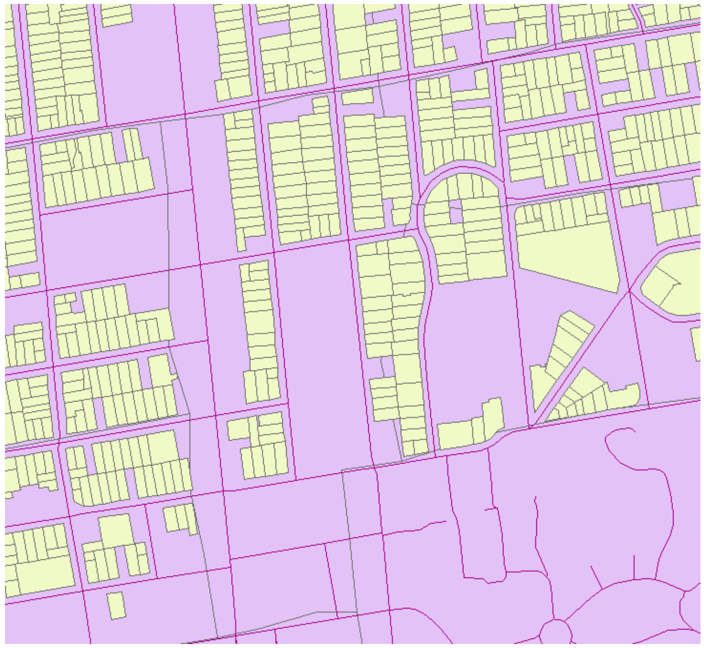
In order to create my map, I compiled data from several different sources, each of which had a different map projection:

1. Transit data that I downloaded from the Metropolitan Transportation Commission (UTM 1983, Zone 10N)
2. Census block group boundaries that I downloaded from ESRI's Tiger database (North American GCS 1983)
3. Ocean shapefiles that I downloaded from Cal-Atlas (NAD 1983 Teale-Albers)
4. Berkeley street, lot, and parcel data provided by Professor John Radke (NAD 1983 California State Plane, Zone 3)

Fortunately, all of these files came with metadata, so all I had to do was view their spatial information in ArcCatalog to figure out what coordinate system they were in. Lacking any particular preference, I decided to use UTM 1983, Zone 10N for my map simply because I loaded the transit data first. After loading each subsequent data layer, I opened the Project tool from the Projections and Transformations section of the Data Management toolbox and chose UTM 1983, Zone 10N as the output coordinate system. None of the projections that I performed required any additional geographic transformations. After loading all of the shapefiles and projecting them into the same coordinate system, my map looked like this:



In some cases the streets and block groups did not appear to be exactly aligned:



However, they were close enough, and the block group boundaries had so many irregular shifts that I wasn't sure if this was due to an error in the projection or discrepancies in the shapefiles themselves. In any case, my project did not require that fine-grained of an analysis, so even if they were misaligned I didn't think that it would distort my results significantly.

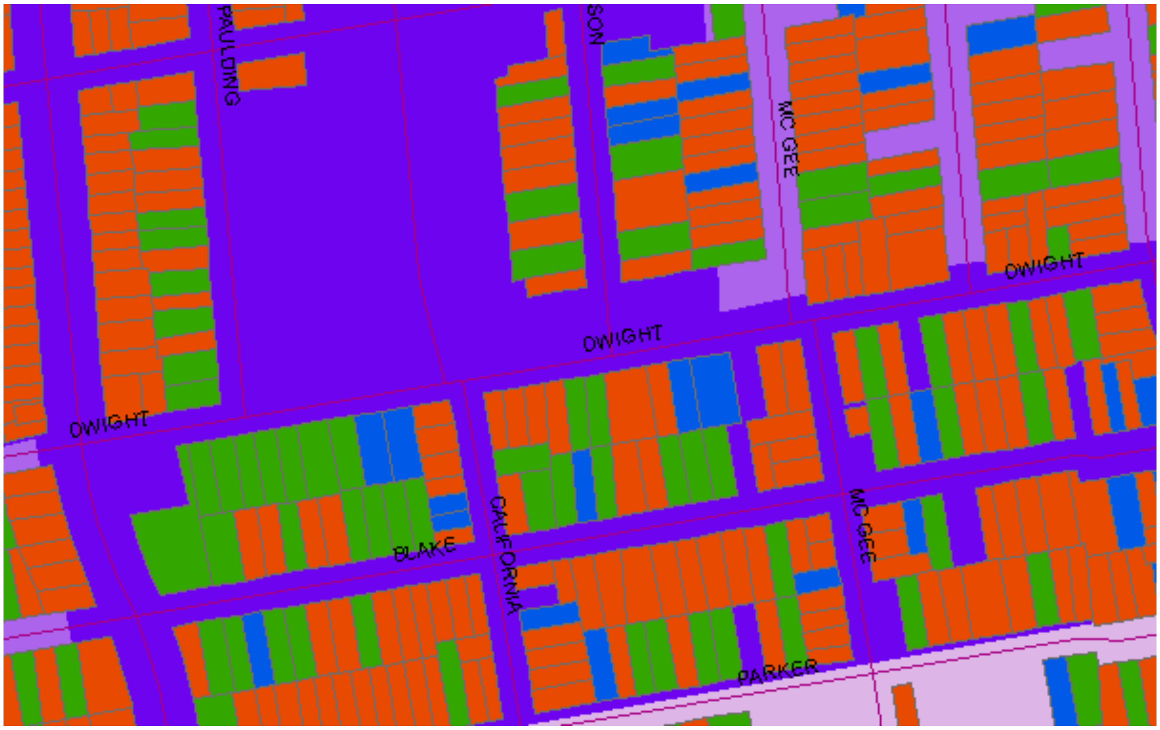
Step 2: Displaying ADU opportunity lots and demographic information

The next step was to determine which lots had space for ADUs. I began by selecting all lots that were not zoned for residential use and deleting them from the layer in order to simplify my analysis. My data also indicated which lots already had permitted secondary units in place, and since our interviews indicated that homeowners who had built ADUs were frequently inspired to do so after seeing similar units on their neighbors' property (West Berkeley homeowners 2009), so I selected all of these lots and created a new layer for them, displaying them in blue. Berkeley limits all ADUs to 25 percent of the floor area of the main unit (City of Berkeley 2008, 139), and I assumed that homeowners would want to built the largest ADU possible. I created a new field in my parcel layer's attribute table and used the field calculator to set the values of the field to:

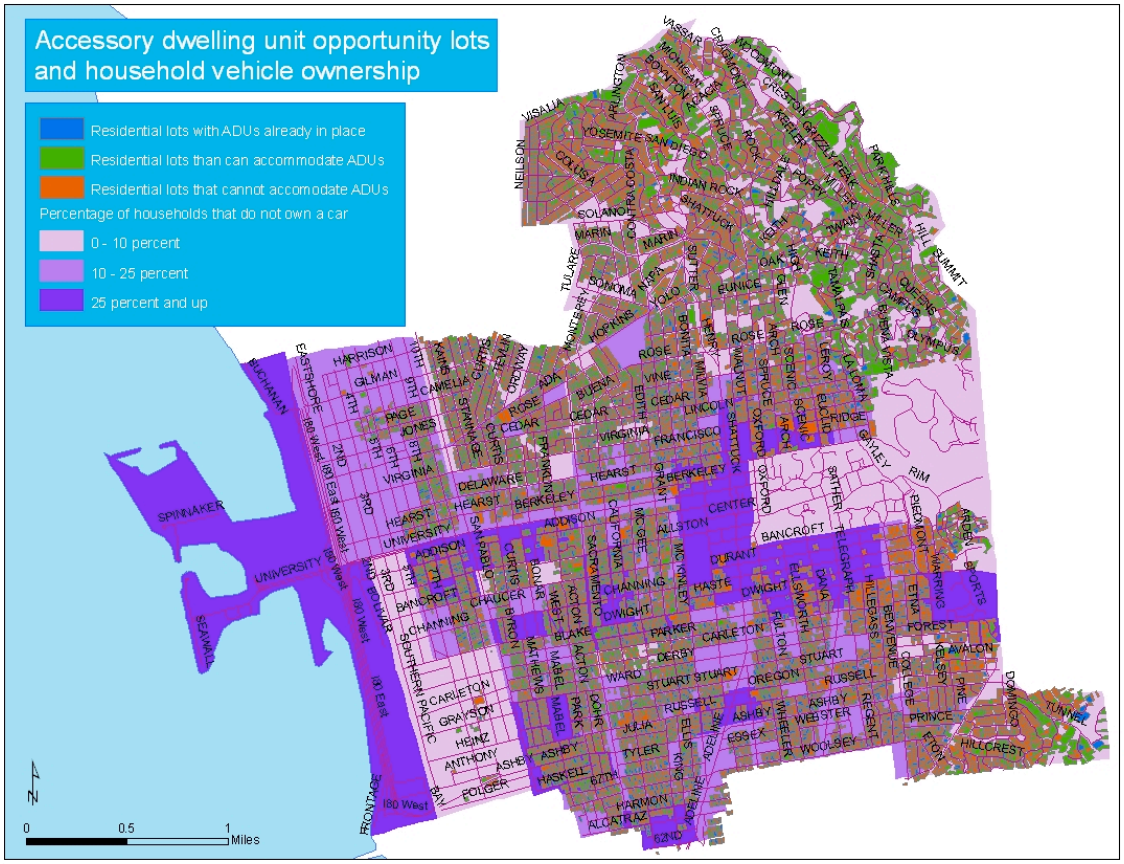
1.25 * bldgSF / lotSF

Where this value was under 0.4, there was space for an ADU that met the city's 40 percent maximum lot coverage requirement. I selected all such parcels that were over 4500 square feet (the minimum required to put up an ADU) and exported them to their own layer.

Next, I needed to get some data on vehicle ownership so that my partners could make the case for waiving parking requirements for ADUs in areas where residents were less likely to own cars. I downloaded household vehicle ownership data for all Berkeley block groups from the 2000 Census, reformatted this data and saved it as a .dbf file, and then joined it to my census block group layer. In order to keep the display simple, I selected and removed all block groups outside of Berkeley. Then I changed the layer's symbology to display the percentage of houses in a block group that don't own a vehicle using a 3-tiered color ramp. Since the map is going to be used for outreach purposes, I set the breaks manually to simple values; 10 and 25 percent. The 10 percent break is also important because research shows that car-sharing programs, discussed in more depth later in this paper, work well in neighborhoods where over 10 percent of households don't own a vehicle (Millard-Ball et al 2005, 3-40). By overlaying this data with the ADU opportunity lots that I just created, my partners will be able to market to target areas of Berkeley where there are lots with ample space for ADUs and where it may be easier to convince planners to waive parking requirements, such as the block in the figure below at the southwest corner of Dwight and California (lots shown in green have space for ADUs, and the dark purple background indicates that over 25 percent of households don't own a car).


PAULDING
SON
MC GEE
DWIGHT
DWIGHT
DWIGHT
BLAKE
CALIFORNIA
MC GEE
PARKER

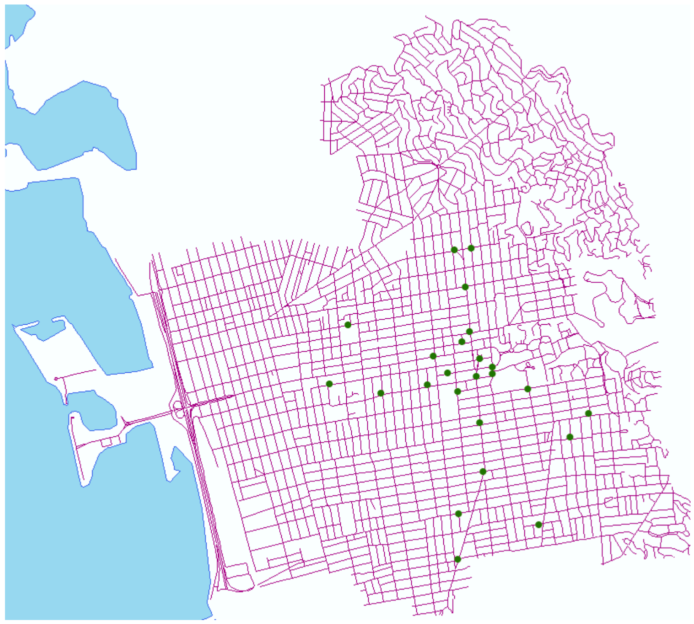
The final map looks like this:



Step 3: Creating new map features

A growing number of Bay Area residents rely upon shared cars rather than personal automobiles, and I wanted to map these facilities. However, I could not find a shapefile containing this data. The main car-sharing provider in the Bay Area is City Car Share, and their website has a map of all their locations (City Car Share 2009). I opened up the Editor toolbar, set it to Start Editing, set the task to Create New Feature, and used the pencil tool to draw in all of the City Car Share locations.

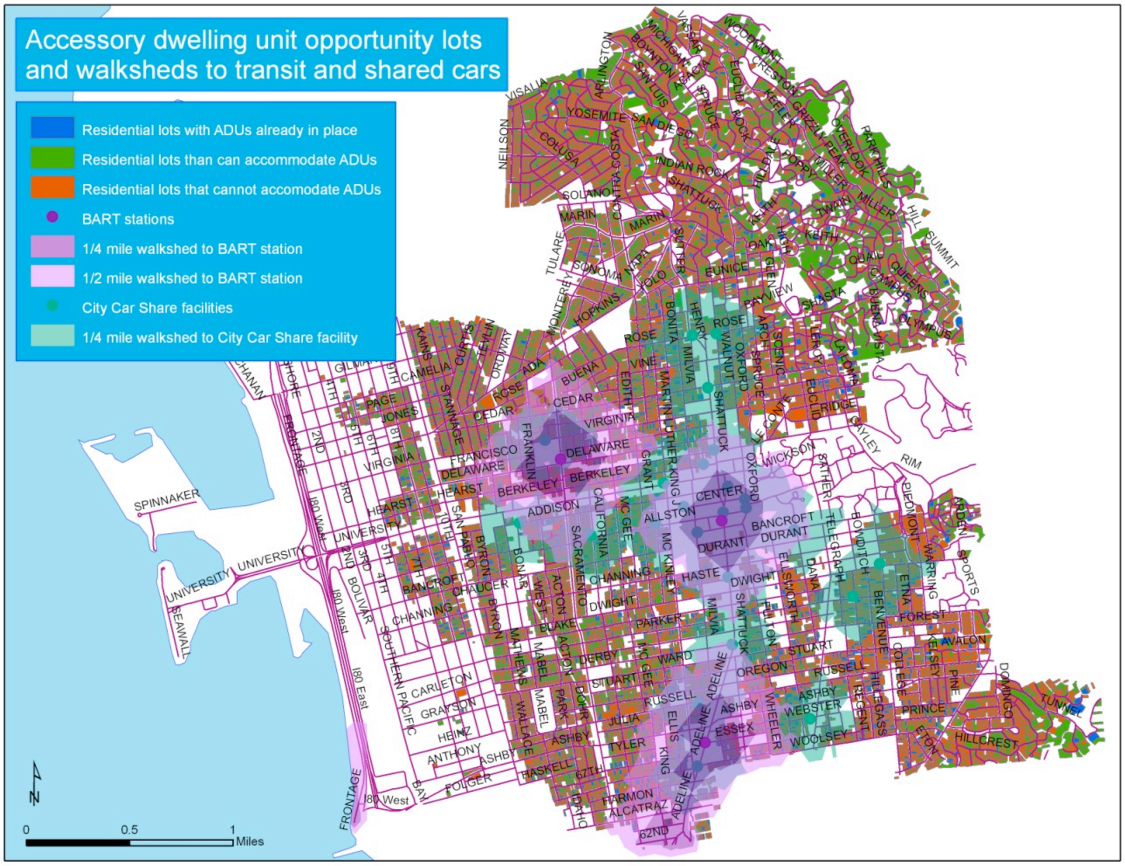
The map below shows all 23 locations where shared cars are parked throughout Berkeley.



Step 4: Displaying walksheds around alternative transportation facilities

Besides looking at vehicle ownership in the surrounding neighborhoods, my partners could also argue that an ADU does not need an extra parking space because it is adequately served by public transportation. Researchers typically define a "transit service area"—the area within which residents are likely to replace personal vehicle trips with transit trips—as anywhere from a quarter- to half-mile radius from a regional transit station (Nelson 2006, Fairfax County 2006), and car-sharing companies look at a similar area when deciding where to site facilities (Makarewicz 2009). However, since car-sharing facilities require a membership and are not yet as widely used as BART, I'm going to limit their capture area to a quarter-mile. I could use a simple buffer to display the radius, but I think that it would be more accurate to look at walksheds using the Network Analyst.

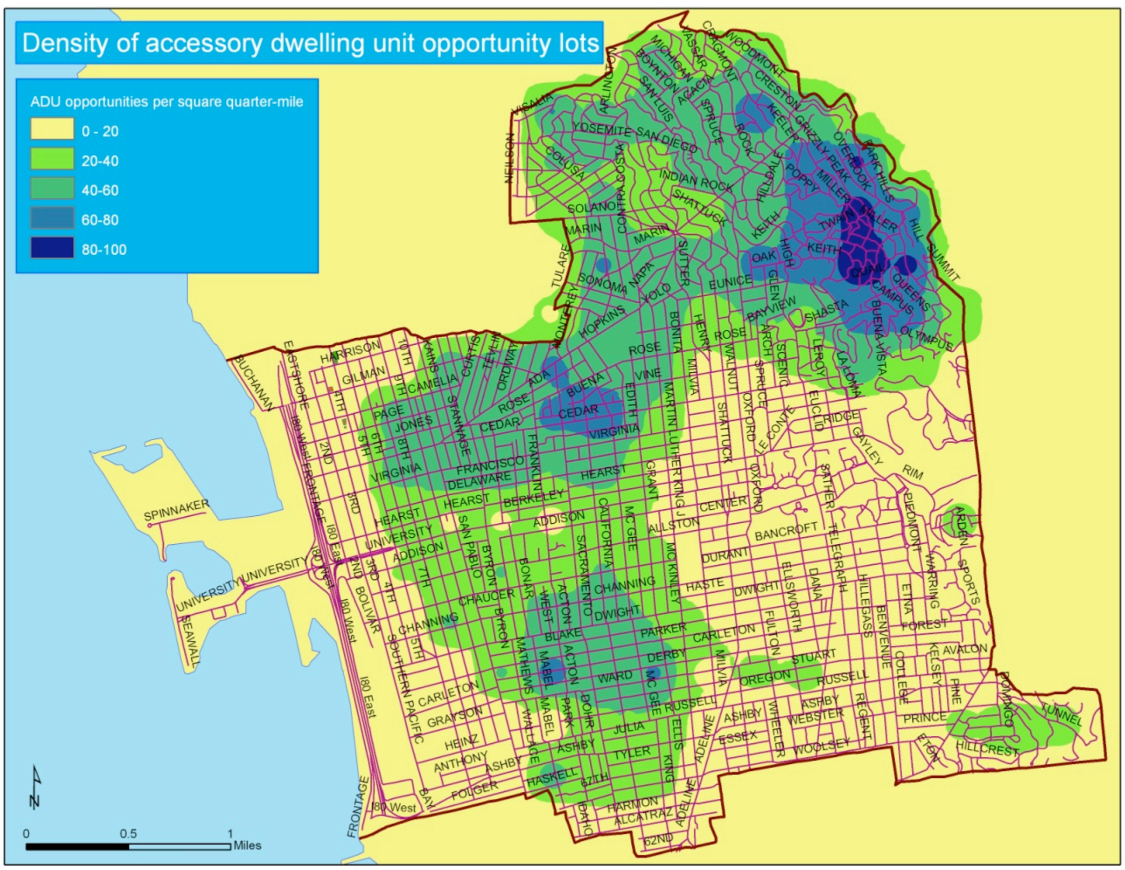
In order to create walksheds, I enabled the Network Analyst and created two new service areas, one for BART stations and one for City Car Share facilities. For BART, I defined the default breaks as a quarter- and half-mile, while I gave City Car Share facilities a quarter-mile default break. Them I ran the Network Analyst and exported the results as a new layer. Here's the result:



Step 5: Analyzing the density of lots with space for ADUs

As a final step, I wanted to create a raster layer showing the density of ADU opportunity lots varying continuously across the city. Though in reality the opportunities for ADU installation vary discretely from lot to lot, this layer would allow my partners to locate areas rich in opportunities without squinting at a bunch of green and orange parcels. Furthermore, my partners may also be able to assist clients in arguing for parking requirements to be waived if they conduct programmatic traffic surveys to see if there is enough off-street parking that there is no need for an off-street space, or if they provide an additional City Car Share facility sited to serve multiple units. However, both of these measures would be expensive, and only worthwhile in the opportunity areas identified in this layer.

In order to complete this step, I first created a point layer with the centroids of all the ADU opportunity lots that I identified in step 2. I used Hawth's tools, an ArcGIS add-on that I downloaded from the www.spatialecology.com/htools/, to create a quarter-grid overlaying that map and count how many ADU opportunity lots were in each grid cell. In order to be consistent with the definition of walking distance used elsewhere in my analysis, I set the cell size to a quarter-mile. Then I created another point layer with the centroids of each grid cell and added a new raster layer with the same extent as my grid to the map. Finally, I opened the Spatial Analyst and performed an inverse distance weighted interpolation of the grid centroids, using the number of ADU opportunity lots in each cell as the Z value. I set search radius to 8 points since in a grid each cell borders on eight other cells, and because there is no reason to expect the number of opportunity lots in distant cells to have any bearing upon each other.



Limitations

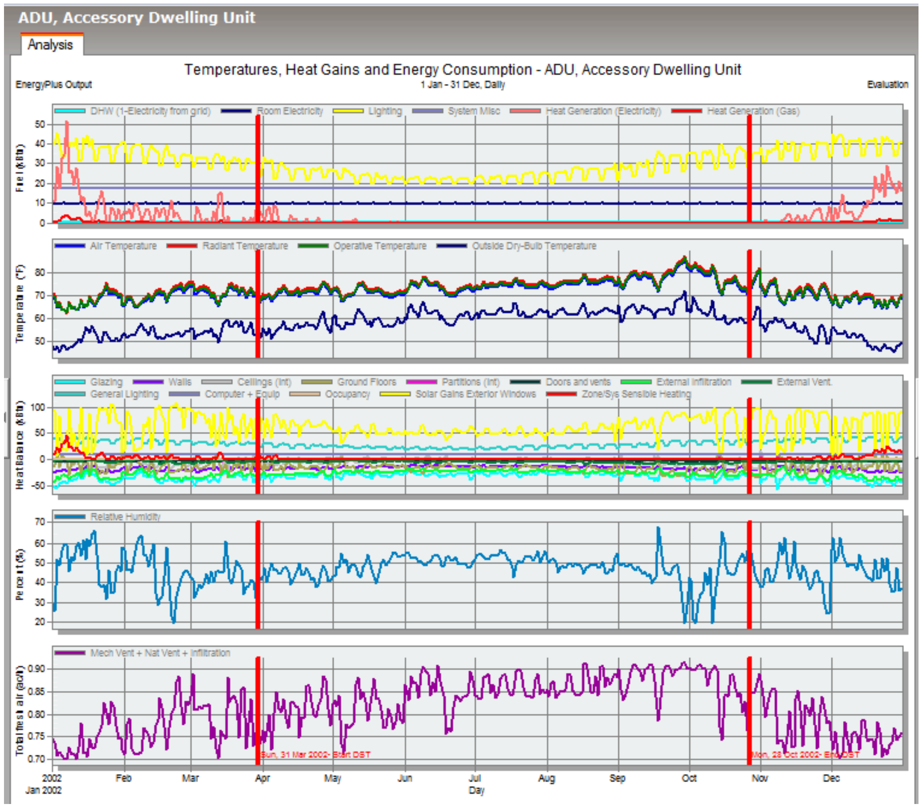
It's unlikely that every lot that I identified could actually accommodate an ADU. Accessory structures not counted in the building square footage nor reflected in my data, trees and shrubbery, and steep grades (particularly in the Berkeley hills) could all pose physical obstacles to ADU construction. Additional zoning constraints, such as setback requirements, further restrict homeowners' ability to build ADUs. Furthermore, census block groups cover a relatively large area, so my map of vehicle ownership does not reflect fine-grained changes such as those one would expect to see within walking distance of transit.

Conclusion

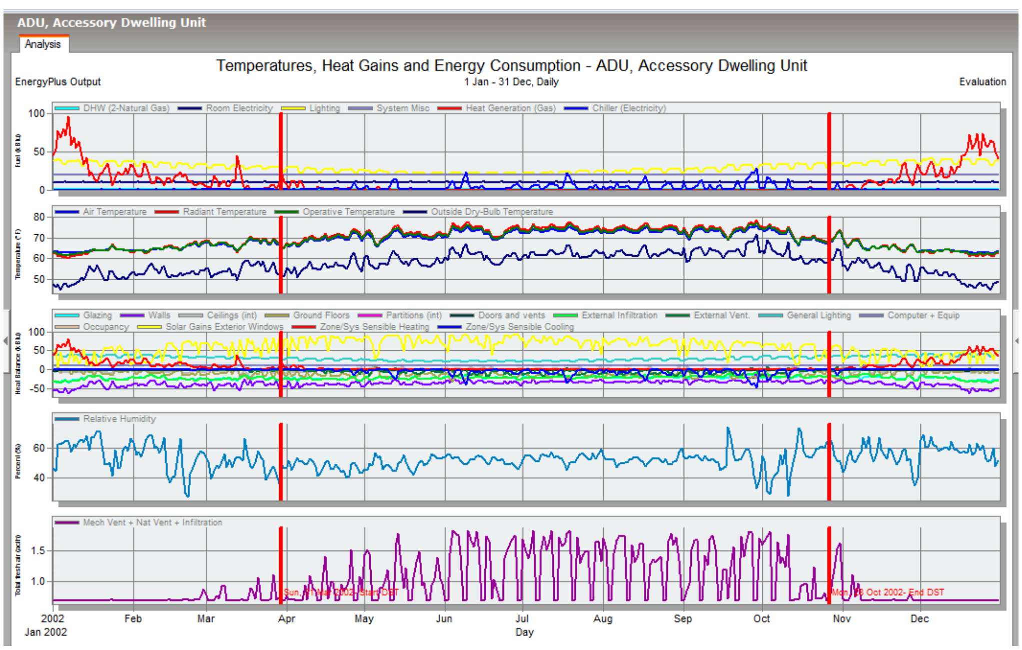
My analysis shows that there are areas with upwards of 40 opportunity lots per square quarter-mile throughout the North Berkeley Hills, North Berkeley, and West Berkeley, as well as in South Berkeley near the intersection of Dwight and California. Even assuming that only one-quarter of the lots that I identified as opportunity lots are actually suitable for ADUs, my partners still have plenty of potential clients in these areas. I'd recommend that they focus on the high-density opportunity pockets that I've identified near the North Berkeley BART station and around the Dwight-Sacramento intersection. Not only are both rich in lots with space for ADUs, but also have characteristics that could potentially mitigate the parking requirements in the zoning code. The former is well served by transit, while the latter coincides with areas of very low vehicle ownership. Though my map does not show parking availability, West Berkeley is the only residential area in the city that has ample enough on-street parking that it does not require parking permits. The high-density opportunity area bounded by San Pablo in the east, 6^{th} St. in the west, Virginia in the south, and Camelia in the north may be a good area in which to conduct a programmatic parking study in order to help clients argue for waiving requirements.

Thanks to Christian Eggleton, Professor John Radke, Carrie Makarewicz, and Cristi Delgado at the City of Berkeley.

Appendix D: Energy Plus Model Output: Design Alternative Comparison



Energy Plus Output for Improved EPS Wall R-20



Energy Plus Output for Baseline Thermalite Wall R-7

Works Cited

Association of Bay Area Governments (ABAG) (2009). Projection 2009 frequently asked questions. www.abag.ca.gov/rss/pdfs/Projections2009FAQ.pdf.

Berg, C. (2009). Director, Santa Cruz Housing and Community Development. Interview conducted by the authors, March 8th, 2009.

Bernstein, F. (2005). In Santa Cruz, affordable housing without the sprawl. The New York Times, February 6th, 2005.
http://www.nytimes.com/2005/02/06/realestate/06nati.html?_r=1&pagewanted=print&position=.

Bourguignon and Pleskovic. Rethinking Infrastructure for Development. Annual World Bank Conference on Development Economics. (2007)

Bourne S, Liu M, Santiago A. "A Comparison of Life Cycle $CO_{2\text{-eq}}$ Emissions between Traditional WoodFramed Homes and Structurally Insulated Panels". University of California Berkeley. 2008.

California Housing and Community Development (2003). Second-unit legislation effective January 1, 2003
and July 1, 2003. http://www.hcd.ca.gov/hpd/hpd_memo_ab1866.pdf.

Cervero, R. (1989). Jobs-housing balance and regional mobility. APA Journal, Spring 1989: 136-150.

City Car Share (2009). East Bay map. http://www.citycarshare.org/eastbaymap.do.

City of Berkeley (2006). Land use planning fees.
http://www.ci.berkeley.ca.us/uploadedFiles/Online_Service_Center/Planning/FeeSchedule2007-21-08.pdf.

City of Berkeley (2008). City of Berkeley municipal code and zoning ordinance, Title 23 (zoning ordinance). http://www.ci.berkeley.ca.us/uploadedFiles/Clerk/Level_3_-_BMC/BMC-Part2--120808.pdf.

City of Berkeley (2009a). Permit fee chart: 1&2 family residence.
http://www.ci.berkeley.ca.us/onlineservice/planning/PermitFeesResidential.pdf.

City of Berkeley (2009b). Climate action plan.
http://www.berkeleyclimateaction.org/docManager/1000000251/BCAP_April%2009.pdf.

City of Livermore (2009). Livermore planning and zoning Code.
http://www.codepublishing.com/ca/LivermorePDF/LivermorePZCfullcode0309.pdf.

City of Palo Alto (2009). Zoning code chapter 18.12: R-1 residential district.
http://www.cityofpaloalto.org/civica/filebank/blobdload.asp?BlobID=8700.

City of Santa Cruz (2009). ADU zoning regulations. http://www.ci.santa-cruz.ca.us/pl/hcd/ADU/PDF/ADU_Zoning_Regulations.pdf.

City of Vancouver (2009a). Laneway housing fact sheet, February 2009. http://www.vancouver-ecodensity.ca/webupload/File/LWH%20Fact%20Sheet%284%29.pdf.

City of Vancouver 2009b). Detailed history: EcoDensity background. http://www.vancouver-ecodensity.ca/content.php?id=38.

Diamond, Rick. Personal interview. 16 April 2009. Interview.

Droettboom, T. (2009). Focused growth for the Bay Area. Presentation to the University of California at Berkeley City Planning 252 class, May 7th, 2009.

El Nasser, H. (2004). "Granny flats" finding home in tight market. USA Today, January 5th, 2004. http://www.usatoday.com/news/nation/2004-01-05-granny-flats_x.htm.

Energy Information Administration. "Voluntary Reporting of Greenhouse Gases". 2007. http://www.eia.doe.gov/oiaf/1605/pdf/Appendix%20F_r071023.pdf.

Energy STAR. "Dishwasher Savings Calculator." 2009. http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls.

Energy STAR. "Refrigerator Savings Calculator." 2009. http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Consumer_Residential_Refrig_Sav_Calc.xls.

Fairfax County Planning Commission, Transit-Oriented Development Committee. Walking distance research. www.fairfaxcounty.gov/planning/tod_docs/walking_distance_abstracts.pdf.

Fulton, W., and Shigley, P. (2005). Guide to California Planning. Point Arena, CA: Solano Press Books.

Holtzclaw et al. Location efficiency: Neighborhood and socio-economic characteristics determine auto ownership and …. Transportation Planning and Technology (2002)

Holtzclaw and Club. Location Efficiency as the Missing Piece of The Energy Puzzle: How Smart Growth Can Unlock Trillion Dollar Consumer Cost Savings

Holtzclaw et al. Explaining urban density and transit impacts on auto use
California Energy Resources Conservation and Development … (1990)

Jones, C. (2007). East Bay mayors, UC chancellor unite for "green wave." San Francisco Chronicle, December 4th, 2007. http://www.sfgate.com/cgi-bin/article.cgi?f=/c/a/2007/12/04/BA9CTNJ5V.DTL.

Landis and Hood. The Future of Infill Housing in California: Opportunities, Potential Feasibility and Demand. infill.gisc.berkeley.edu (2005)

MacDonald, E. (2009). Developer, Hudson MacDonald. Interview conducted by the authors, April 28th, 2009.

McKinley, S. (2009). Developer, Hudson MacDonald. Interview conducted by the authors, April 15th, 2009.

Meigs, N. (2009). University of California Berkeley Master's in City Planning student. Interview conducted by the authors, March 13th, 2009.

Mendez, L. (2009). Planer, Land Use Planning Division, City of Berkeley. Interview conducted by the authors. March 16th, 2009.

Napa County Transportation and Planning Agency (NCTPA) (2009). Napa's transportation future, chapter 3: projections for 2035. napastransportationfuture.googlepages.com/NTFChapter3.pdf.

Nielsen Inc. (2004). Claritas SiteReports, Berkeley demographic snapshot. Cited on the Panoramic Management webpage, http://www.panoramicmanagement.com/.

Nelson, A. (2006). Leadership in a new era. Journal of the American Planning Association 72(4): 393-409.

Orjala, J. (2009). Berkeley homeowner and principal, Orjala Architects. Interview conducted by the authors, March 6th, 2009.

Paull. Energy Benefits of Urban Infill, Brownfields, and Sustainable Urban Redevelopment. nemw.org (2008)

Powell, G. (2009). Senior planner, Land Use Planning Division, City of Berkeley. Interview conducted by the authors, March 2nd, 2009.

Romain, B. (2009). Sustainable Development Coordinator, City of Berkeley. Interview conducted by the authors, April 17th, 2009.

Santa Cruz Housing and Community Development (2009). Accessory dwelling unit development program. http://www.ci.santa-cruz.ca.us/pl/hcd/ADU/adu.html.

Sorenson, G. (2009). Planner, Land Use Planning Division, City of Berkeley. Interview conducted by the authors, March 6th, 2009.

West Berkeley homeowners (2009). Interviews conducted by the authors, March 1st, 2009.

Western Resource Advocates. Urban Sprawl: Impacts on Urban Water Use.